

CHEMICAL ENGINEERING

Paper – II

Time Allowed : Three Hours

Maximum Marks : 200

Question Paper Specific Instructions

Please read each of the following instructions carefully before attempting questions :

*There are **EIGHT** questions in all, out of which **FIVE** are to be attempted.*

*Questions no. 1 and 5 are compulsory. Out of the remaining **SIX** questions, **THREE** are to be attempted selecting at least **ONE** question from each of the two Sections A and B.*

Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off.

All questions carry equal marks. The number of marks carried by a question/part is indicated against it.

*Answers must be written in **ENGLISH** only.*

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

Assume suitable data, if necessary, and indicate the same clearly.

Neat sketches may be drawn, wherever required.

SECTION A

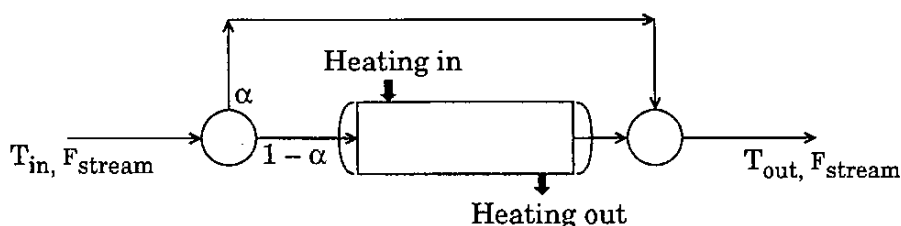
Q1. Answer each of the following questions :

5×8=40

- (a) Explain the merits and demerits of oxycombustion versus regular combustion of fuels. 5
- (b) Give one example each of bypass, recycle and purge in a chemical flow reacting system, and explain their importance. 5
- (c) What is meant by fuel NO_x and thermal NO_x ? How are they minimized ? 5
- (d) Explain the importance of Le Chatelier's principle with an example. 5
- (e) Write the Vapour Liquid equilibrium equation for a system having non-ideality only in the gas phase. 5

- (f) Explain the term Coefficient of Performance (COP) in refrigeration systems. 5
- (g) Explain the main difference between plug flow reactor and continuous stirred tank reactor. 5
- (h) When are semi-batch reactors preferred over batch reactors? 5

Q2. (a) A heat exchanger is used to heat up a process stream. The configuration has a bypass of the process stream as shown below :



The mass flow rate of the process stream is F_{stream} and gets split with a fraction α as bypass. Given that the process stream has a specific heat of C_p and a fixed amount of heat Q is delivered by the heating medium, estimate the outlet temperature of the process stream as a function of α . 20

- (b) What are the desirable properties of a refrigerant that are typically used in a refrigeration cycle? 10
- (c) What is a Horton sphere? What is it used for and why? 10

- Q3.** (a) Using an example, explain what is reactive distillation. What are the requirements for reactive distillation to be feasible? 10
- (b) A spherical coal particle with 40% ash (uniformly distributed) is to be burnt. Describe the phenomena in the following two cases : 20
- (i) Combustion is controlled by diffusion of oxygen in the surrounding air.
- (ii) Combustion is controlled by diffusion of oxygen in the ash layer.
- (c) A binary vapour mixture of benzene and toluene containing x mole fraction of benzene is cooled at constant pressure P . Outline the method to estimate the dew point of the mixture and the liquid phase composition. 10

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- Q4. (a) Explain the term chemical potential and its use. 10
- (b) How is power generated in a thermal power plant ? Explain with a neat diagram(s). 15
- (c) Two waste streams, the first containing 100 m^3 per hour of 0.1 N HCl , and the second containing 200 m^3 per hour of 1 N HNO_3 , are charged into a neutralization pit having volume 1000 m^3 . Estimate the flow rate of 1 N base that would be needed to enable acceptable discharge from the neutralization pit. 15

SECTION B

Q5. Answer each of the following questions :

5×8=40

- (a) Explain why and when biomass gasification would be preferred over combustion. 5
- (b) What are the major solid wastes from forests ? How would you use or dispose them ? 5
- (c) Explain the molecular level aspects that provide cleansing action in soaps and detergents. 5
- (d) Explain what is meant by Global Warming Potential (GWP). Arrange the following in increasing order of their GWP :
Steam, Methane, CO₂. 5
- (e) What is flyash ? What are its sources and what is its environmental impact ? 5
- (f) Explain the factors that influence optimal design of waste heat recovery systems. 5
- (g) What are the important sinks of CO₂ ? Explain the role of forests as sources/sinks of CO₂. 5
- (h) What is steam reforming of methane ? What is it used for ? 5

- Q6.**
- (a) Explain the process of cement production with a neatly labelled diagram. 15
 - (b) Explain what is meant by first generation biofuels. What are the drawbacks of these fuels ? 10
 - (c) Write a brief note on PERT/CPM. 15

- Q7.**
- (a) Explain the process of producing ethylene using a neatly labelled flow diagram. 15
 - (b) Describe the process of production of bio-diesel via trans-esterification of fatty acids/oils. 15
 - (c) Outline the different methods of asset depreciation and analyze their impact on determining the profitability and payback. 10

- Q8.**
- (a) Explain the steps in the production of ammonia from the Haber Process using a neatly labelled flow diagram. 15
 - (b) Describe two methods of air pollution control. Compare the treatment methods. 15
 - (c) Explain the discounted cash flow method for assessing the profitability of a project. 10